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**MILITARY PRODUCTS FROM COMMERCIAL LINES**  
**EXECUTIVE SUMMARY**

TRW  
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This technical report has been reviewed and is approved for publication.

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The Industrial Base Pilot (IBP) Military Products from Commercial Lines (MPCL) program demonstrated the production of military electronics products on commercial manufacturing lines, showing cost reductions, improved quality and equivalent performance. The successful completion of this project provided the Department of Defense a demonstration of a process that meets defense requirements using commercial sources			
The MPCL project consisted of three major focus areas. An integrated product team (IPT) was formed to address each focus area. The IPTs consisted primarily of representatives from TRW Avionics System Division (TRW ASD), TRW Automotive Electronics North America (TRW AEN), Air Force Manufacturing Technology, Lockheed Martin Tactical Aircraft Systems (LMTAS), Lockheed Martin Aeronautical Systems (LMAS), Boeing/Sikorsky, F-22 System Program Office and the Comanche Helicopter (RAH-66) Program Management Office. Numerous other Government organizations were also represented to provide specific expertise to each of the IPTs. The three focus areas are Process Technology, Business Practices, and Manufacturing Infrastructure.			
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The Process Technology (PT) team redesigned and built military avionics hardware on a commercial assembly line at the TRW AEN Marshall, IL plant. Results confirmed that both cost and performance objectives can be met. Significant cost savings (50% -70%) for the MPCL modules have been confirmed by actual procurement and assembly and test data. In addition, extensive reliability and durability testing shows that commercial parts and processes are robust enough to meet or exceed F-22 and RAH-66 requirements

Business Practices (BP) involves developing the contractual and operational mechanism to integrate a military customer and a commercial supplier. The BP team developed commercially acceptable replacements to military specifications, standards, and contract terms to enable the procurement of military products from commercial sources.

The Manufacturing Infrastructure (MI) team implemented a computer integrated manufacturing (CIM) system that links TRW ASD's design center with the Marshall plant's automated assembly equipment. The CIM system instantiated a design for manufacturing process that optimized performance, price and production objectives. The CIM system included the integration of design and production environments as well as

flexible production cells that allow for seamless transition from commercial products to military products.

## Process Technology

The goals for the PT team are listed below. Each of the goals was achieved.

- Phase I (Conceptual Design): Perform conceptual design trades for design packaging approaches (Plastic vs. ceramic and Chip on Board, vs. leaded vs. area array packages); focus on design rules for commercial assembly.
- Phase 2 (Detailed Design): Perform detailed design and construct design validation (DV) modules in the TRW AEN plant; demonstrate durability and reliability of the “commercial versions” of the design.
- Phase 3 (Production Validation): Update the design and build 120 production verification units (PV) in the Marshall plant; demonstrate a 15 minute line conversion and implement BP team recommendations. Make these modules available to the F-22 and RAH-66 programs.

In the conceptual design phase of the program, concerted effort was spent assimilating TRW AEN design for manufacturing rules and requests into the TRW ASD design infrastructure. Design candidates were quantitatively scored in decision matrix methodology and the manufacturing line was selected.

In the detail design phase of the program, risks identified under the conceptual design phase were analyzed or tested. New filter circuitry using commercial components was analyzed and breadboarded. Durability testing of the Plastic Ball Grid Array (PBGA) package solder joints was performed, and exhaustive testing of commercial-off-the-shelf (COTS) plastic encapsulated microcircuits (PEMs) and commercially packaged ASICs were performed. Sixty DV units of two module types, thirty each, were produced to verify the detailed design and manufacturing processes.

In the last phase of the program, the detailed designs were updated to fix shortcomings identified by the DV unit builds and (116) PV units were built. These units were exposed to the full battery of tests used on the military version predecessors: Design Verification Tests, Acceptance Tests, Environmental Stress Screening, Durability Life

Tests, and other Verification and Validation Tests at the module level. DV and PV units have also been placed into next higher assemblies, aircraft racks, and continue to experience rack tests. By the end of 1999, MPCL modules will have been through rack safety of flight testing and will be deployed for F-22 EMD aircraft integration.

The results of these activities have demonstrated a 54% cost reduction on one module and a 73% reduction on the second module. The module weights have been reduced by 35%. Durability testing indicates that at least one full 20-year lifetime of military fighter environments can be achieved utilizing commercial parts and processes. Component reliability far in excess of 12,000 hours has been demonstrated by accelerated tests. Full functional compatibility with the predecessor military module has been verified by design verification tests.

### **Business Practices**

The Business Practices activity operated during the whole four-year tenure of the MPCL project. From the beginning, attacking business practice barriers was the project's highest priority. Commercial companies simply would not do business under the traditional military acquisition system; therefore, developing new process technologies or manufacturing infrastructures would be fruitless unless business practice barriers could be overcome.

The success of this activity has been striking. Business practices developed under this program are serving as a model for streamlined acquisition and for implementation of a commercial alternative to Military Standards.

MPCL has changed the way military and commercial contractors view each other. From the military perspective, commercial contractors are now seen as sources of high quality products and significantly reduced prices. Military contractors have bought into the idea that commercial quality control processes provide more than adequate replacements for military specifications and standards. This realization came about after testing conducted under the PT activity. The MPCL project has replaced perceptions with facts, thus overcoming much of the fear experienced by commercial suppliers when contemplating doing business with the military. MPCL has convinced both sides that there can be a win-win scenario.

MPCL has provided products to enable a successful merger of the military and commercial business practices paradigms. The two primary products are a Model Subcontract and Business Practices Manual. The Model Subcontract provides a template from which a military buyer and commercial seller can arrive at mutually agreeable terms and conditions. The MPCL Business Practices Manual provides an alternative to military specifications and standards. It is based on ISO-type processes; therefore, commercial companies feel quite comfortable with the general approach. Electronic versions of the Model Subcontract and Business Practices Manual will be available on the web.

The BP Activity, like the entire MPCL project, was divided into three phases. In Phase I, new business practice concepts were developed. Business practices were parsed into two types – contractual and technical. Activities on the contractual and technical BPs proceeded in parallel, with separately operating IPTs. The analysis of the contractual BPs resulted in the draft Model Subcontract, while analysis of the technical BPs resulted in the Business Practice Manual. In Phase II, the Model Subcontract was demonstrated by negotiating a contract between TRW ASD and TRW AEN. The BP Manual was referenced in that contract. Phase II focused on the MPCL project participants while Phase III broadened that focus to additional commercial suppliers. The activities of Phase III endeavored to validate the findings of MPCL with commercial electronics suppliers. Commercial suppliers, especially small companies, can do more business with defense contractors and the DoD. Companies that already operate with a large product mix and small lot sizes find military products to be a potentially valuable source of revenue.

### **Manufacturing Infrastructure**

A key component of MPCL was the development of a world class Computer Integrated Manufacturing (CIM) system to integrate the military design environment with the commercial manufacturing environment. This system was designed to facilitate the production of military electronics on commercial lines. The CIM incorporates the following features.

- Product Design - Computer Aided Design (CAD) tools were integrated with a Product Data Management architecture system to enable flow of design data between the design and production centers.
- Design-Driven Production - An information transfer process was developed that allows design data to drive the factory planning and product launch process. This system uses CAD files to fully program the factory systems, significantly reducing launch time. All information required to build the product is included in the system.
- Product Quality Modeling - A modeling tool was developed to estimate production quality throughout the design and production life cycle. This tool determines first pass yield, production quality issues and defect levels as delivered to the customer.
- Automatic Product Changeover and Process Mistake Proofing - This function supports fast product changeover between military and commercial products and insures the changeover is complete and accurate. For example, the system insures that the correct production materials are loaded into the correct operation slots. The system also checks production route, process time limits and limits on the number of times a process may be repeated on a single unit.
- Factory Control - This function includes a common set of applications that provide factory level command, control and reporting functions. “As-built” data can be obtained from this system along with configuration data. Tools to change system and factory setup are also included.
- Work Cell Control - The Work Cell Control function controls the production floor, providing production workers with quality and setup information along with system status and process instructions. Each production work cell has a computer that provides the interface point to the line. Bar code scanners and machine control logic are routed through these computers to minimize line wiring and support.
- Centralized Production and Quality Data Model - All factory information is controlled and contained in a single data model. All functions in the factory share this data model including the Work Cell Control and Factory Control.
- Highly Modular and Transferable Information System - The CIM system is designed using rapid deployment modular design to permit transfer to other sites.

MI Phase I activities concentrated on installing and demonstrating the distributed design environment in support of the PT team. The distributed design environment allows interactive review of design alternatives by manufacturing engineers and supports this review across various geographical locations. Phase II focused on designing the flexible factory systems required to produce both small and large lot sizes economically on the same line. During Phase III, the MI team deployed and demonstrated the factory systems and the complete system functionality.

The MI IPT was successful in purchasing, developing, and deploying these capabilities at the TRW AEN Marshall plant. The Marshall Flex 3 production line is currently equipped with the MPCL CIM system. Both MPCL and commercial automotive products have been built using the CIM system, and the MPCL data model is being used for all TRW Marshall plant quality and performance data. Remote control of the Marshall factory control and work cell control functions from TRW ASD in San Diego has been demonstrated.

### **Summary**

MPCL has helped create a new future that offers military products at reduced cost and improved quality. This future is possible because MPCL has opened up the supplier base to commercial sources and enabled the transaction between military contractors and commercial suppliers to occur. The pilot program successfully demonstrates that building military products on commercial lines is technically and economically feasible and provides the tools and processes for applying MPCL concepts to DoD systems.

## **For Further Information**

Results of the MPCL program are detailed in several volumes of the final report as shown below. These volumes may be available through the AFRL Materials and Manufacturing Directorate web site, [www.ml.wpafb.af.mil](http://www.ml.wpafb.af.mil), or by contacting the AFRL/ML Technology Information Center at [techinfo@ml.wpafb.af.mil](mailto:techinfo@ml.wpafb.af.mil), or (937) 256-0194.

### **MPCL Final Report**

Executive Summary

Volume I – Business Practices

Volume IA – Business Practices Manual

Volume II – Manufacturing Infrastructure

Volume III – Process Technology (Limited Distribution)

Volume IIIA – Process Technology

Volume IV – Lessons Learned